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TI Iron-nickel-chromium-aluminum ferritic alloy and  
manufacture thereof  
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PA Hitachi Metals, Ltd., Japan  
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AB An alloy suitable for wear-resistant parts and parts contacting with molten metals contains C .ltoreq.0.05, Si .ltoreq.2, Mn .ltoreq.2, Ni .gtoreq.2 and .ltoreq.15, Cr .gtoreq.15 and <20, Al 2-8, and Ti, Zr, Hf, V, Nb, Y, and/or REM 0.05-1.0%.  
The alloy is manufd. by molding, heating at 800-1300.degree. in an oxidizing atm., forming a film mainly contg. Al<sub>2</sub>O<sub>3</sub> on the surface, and then cooling at a rate higher than the air cooling rate.

# PATENT ABSTRACTS OF JAPAN

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(54) IRON-NICKEL-CHROME-ALUM. FERRITIC ALLOY AND ITS PRODUCTION

(57)Abstract:

PROBLEM TO BE SOLVED: To produce an Fe-Ni-Cr-Al ferritic alloy excellent in molten metal erosion resistance and having extremely good workability and to provide a method for producing the same.  
SOLUTION: This alloy has a compsn. contg., by weight,  $\leq 0.05\%$  C,  $\leq 2\%$  Si,  $\leq 2\%$  Mn, 2 to  $<15\%$  Ni, 15 to  $<20\%$  Cr, 2 to  $8\%$  Al and one or  $\geq$  tow kinds among Ti, Zr, Hf, V, Nb, Y and rare earth metals by 0.05 to  $1.0\%$ , and the balance substantial Fe with inevitable impurities. Furthermore, as for the method for producing the same, this alloy stock is formed into a prescribed shape, which is held under heating in an oxidizing atmosphere heated at 800 to  $1,300^{\circ}\text{C}$ , then, a film essentially consisting of the oxide of aluminu is formed on the surface of the member, and after that, cooling is executed at a rate of that in air cooling o above.

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CLAIMS

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[Claim(s)]

[Claim 1] The Fe-nickel-Cr-aluminum system ferrite alloy with which the remainder is substantially characterized by the bird clapper from an unescapable impurity C:0.05% or less by the weight ratio at Fe row one sort of less than [ Si:2% ], less than [ Mn:2% ], less than [ more than nickel:2%15% ], less than [ more than Cr:15%20% ], aluminum 8%, and Ti, Zr, Hf, V, Nb, Y and rapid eye movement, or : 0.05 to 1.0%

[Claim 2] By the weight ratio, C:0.05% or less, less than [ Si:2% ], less than [ Mn:2% ], less than [ more than nickel:2%15% ], Cr: Less than [ more than 15%20% ], aluminum:2-8%, and Ti, Zr, One sort or the Fe-nickel-Cr-aluminum system ferrite alloy with which the remainder is further characterized by the bird clapper from an unescapable impurity substantially : [ two or more sorts of ] 0.05 to 1.0% at Fe row one sort of W, Mo, and Co, or : [ two or more sorts of ] 0.2 to 2.0% of Hf, V, Nb, Y, and rapid eye movement.

[Claim 3] the inside of a 800-1300 degrees C [ after fabricating the alloy material which consists of composition of claims 1 or 2 in a predetermined configuration ] oxidizing atmosphere -- heating maintenance -- carrying out -- a member -- the manufacture method of the Fe-nickel-Cr-aluminum system ferrite alloy characterized by cooling the speed more than air cooling after making the coat which makes the oxide of aluminum a subject form in a front face

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the Fe-nickel-Cr-aluminum system ferrite alloy used as metal molten-metal contact members, such as metal mold, and the part, nesting, and a wear-resistant member, and its manufacture method.

[0002]

[Description of the Prior Art] Usually, in case the molten metal of metallic materials, such as an alloy which makes a subject Fe, nickel, Co, aluminum, Zn, Cu, Mg, or these metals, is cast, steel, such as a die steel between heat, high-speed steel, and stainless steel, has been conventionally used for metal molten-metal contact members, such as metal mold. In the portion in which a metal molten metal contacts the above-mentioned ferrous material, these ferrous materials carried out the erosion by the metal molten metal, and increased the iron content in a metal molten metal, and there was a fault in which the quality of casting parts is reduced. Furthermore, erosions, such as these metal mold, produced operation top various un-arranging, such as the poor skin, the cast, and metal mold of a cast welding, and producing a poor mold-release characteristic, and had the problem from which the function of a member falls at an early stage, and serves as a short life.

[0003] In order to solve these troubles, perform surface treatment, such as carburization and nitriding, to the front face of a member which manufactured from the ferrous material conventionally. The proposal which covers a front face with the physical vapor deposition represented by a plasma-chemistry vacuum deposition, the sputtering method, etc a nitride besides [ a hard layer is made to form in ] a method, carbide, a boride (for example, TiN, TiC, BN, SiC, Si<sub>3</sub>N<sub>4</sub>, TiB<sub>2</sub>, aluminum 2O<sub>3</sub>), etc. or the welding method, a shrinkage fit method, etc. is made (JP,56-111560,A, JP,59-21416,A, JP,59-33128,A, JP,60-178017,A, JP,61-33734,A). Moreover, on the other hand, a part of material of the ceramic system which hardly reacts to molten metal, W alloy which cannot start an erosion easily, Mo alloy, etc. are used.

[0004]

[Problem(s) to be Solved by the Invention] Since a deep processing layer is not only obtained by the member manufactured from the above-mentioned ferrous material, but carburization and the nitrided surface treatment layer a diffusion process and there is no problem of ablation in it, it is mostly used in combination with the quality of the material developed on the assumption that these processings were carried out to it. Moreover, it is mentioned that the greatest advantage of such surface treatment is very cheap. However, compared with a conventional aluminum containing alloy and a conventional zinc alloy, use of the aluminum containing alloy of a high-melting point or a zin alloy has increased by high intensity-ization of casting parts in recent years as a cast material.

[0005] therefore, the metal mold carried out from the former -- C in a surface treatment layer and N carried out back diffusion of gas of what performed carburization or nitriding treatment to the surface section into the metal molten metal by the temperature up at the time of work, and the problem which the fall of an original erosion-proof nature function produces came out of it Moreover, there was a fault which the phenomenon of expansion of volume arising since a detailed crack is accepted, a molten metal permeates by making this crack into a path, it reacts with the iron i the base material directly under an enveloping layer and an alloy is formed into an enveloping layer when covering a using the hard matter of a ceramic system by the chemical vapor deposition and the physical vapor deposition, consequently making an enveloping layer exfoliating generates. Furthermore, the material of a ceramic system, W alloy, and Mo alloy were very expensive, and when used as nesting, they were neither the various problems by the difference of a coefficient of thermal expansion with a surrounding ferrous material being large, nor the thing which

breaks, and there is which insufficient problem of the intensity to a chip etc., toughness, and a thermal shock resistant and can not necessarily be satisfied.

[0006] The purpose of this invention is offering the Fe-nickel-Cr-aluminum system ferrite alloy which is excellent in the erosion-proof nature and abrasion resistance based on the new view which solves the problem of these above, and has very good processability, and its manufacture method.

[0007]

[Means for Solving the Problem] Conventionally, it is known well that the quality of the material of a ceramic system will hardly react with molten metal. However, when the quality of the material of a CERAMMIKUSU system is applied to metal mold etc., as mentioned above, there are various troubles and the present condition is being unable to desire improvement in the mold life beyond carburization and the surface treatment using diffusion by nitriding, and cost-predominance. Then, the artificer used the ferrous material for the base material, is the composition which may make a front face generate the coat which makes a subject the aluminum oxide which is oxide system ceramics by carrying out high temperature oxidation of this, and raised molten-metal-proof erosion nature and abrasion resistance and considered proper composition which is of the same grade as the conventional metal mold or a wear-resistant member about processability. Consequently, an alloy new as basic composition is found out for an Fe-Cr-nickel-aluminum system ferrite alloy. While this invention alloy consists of a chemical composition shown below and having the outstanding plastic-working nature, it is one of the big features to make erosion-proof nature and the coat which makes a subject the oxide of the aluminum which reached or was excellent in abrasion resistance form in the work face of a member at least by oxidation treatment after fabrication.

[0008] The 1st invention of this invention by the weight ratio Namely, C:0.05% or less, less than [ Si:2% ], Mn: Less than [ 2% ], less than [ more than nickel:2%15% ], less than [ more than Cr:15%20% ], aluminum: The remainder is Fe-nickel-Cr-aluminum system ferrite alloy substantially characterized by the bird clapper from an unescapable impurity at Fe row one sort of 2-8%, and Ti, Zr, Hf, V, Nb, Y and rapid eye movement, or : [ two or more sorts of ] 0.05 to 1.0%.

[0009] The 2nd invention by the weight ratio Moreover, C:0.05% or less, less than [ Si:2% ], less than [ Mn:2% ], nickel: Less than [ more than 2%15% ], less than [ more than Cr:15%20% ], aluminum:2-8%, Ti, Zr, Hf, V, Nb, Y, and one sort or : [ two or more sorts of ] 0.05 - 1.0% of rapid eye movement Furthermore, it is the Fe-nickel-Cr-aluminum system ferrite alloy with which the remainder is substantially characterized by the bird clapper from an unescapable impurity at Fe row one sort of W, Mo, and Co, or : [ two or more sorts of ] 0.2 to 2.0%. This invention is characterized by adding one sort of W, Mo, and Co, or two sorts or more in 0.2 - 2.0% of range further to the 1st invention.

[0010] the inside of a 800-1300 degrees C [ after the 3rd invention furthermore fabricates the alloy material which consists of composition of the 1st invention or the 2nd invention in a predetermined configuration about the oxide skin forming method of the above-mentioned invention alloy ] oxidizing atmosphere -- heating maintenance -- carrying out a member -- after making the coat which makes the oxide of aluminum a subject form in a front face, it is the manufacture method of the Fe-nickel-Cr-aluminum system ferrite alloy characterized by to cool the speed more than a cooling

[0011]

[Embodiments of the Invention] The reason for limitation of the chemical composition of an Fe-nickel-Cr-aluminum system ferrite alloy and operation concerning this invention are described below.

[0012] In order that C may combine with Cr contained into this invention alloy, Ti, Zr, Hf, V, Nb, W, Mo which are added alternatively, etc., may form carbide and may reduce the addition effect of these elements, its method of a low desirable. Moreover, if the content of C increases, it will also become the cause that the coat which makes a subject the oxide of the aluminum formed during oxidation treatment of a member by CO<sub>2</sub> gas which occurs from a base material surface is destroyed. However, although the upper limit is made into 0.05% since C is mixed from a raw material and costs increase also to decarbonization refinement, it is 0.01% or less desirably.

[0013] Si is a very effective element, in order to raise the fluidity nature of this alloy and to manufacture a healthy in at the time of casting in manufacture of the Fe-nickel-Cr-aluminum system ferrite alloy of this invention. A part exists as oxides, such as SiO<sub>2</sub>, in the coat which makes a subject the oxide of the aluminum made to form in a front face. moreover, the member which consists of this invention alloy -- In order to make porous moderately the coat which makes a subject the oxide of the aluminum which the compactness of a coat is reduced and is formed in a front face high-temperature-oxidation processing, when it is used as a die-casting die, the degassing nature and the mold-release

characteristic of the gas which occurs from molten metal are improved at the time of casting -- making -- moreover, low pressure casting -- public funds -- the case where it is used as type -- metal mold -- the peeling resistance of the paint applied to a front face is raised however, ablation of the coat to which the compactness of the coat which make the oxide of aluminum a subject will fall remarkably, and will make the oxide of aluminum a subject during use if contained exceeding 2% -- being generated -- casting -- public funds -- since it stops being suitable for the use as typ the upper limit of Si is made into 2% The desirable range of Si is 0.3 - 1.5%.

[0014] Mn acts as deoxidation and a devulcanizing agent, and it is added in order to raise the cleanliness of an alloy. However, since hot-working nature will fall if it adds exceeding 2%, the upper limit of Mn is made into 2% or less. While nickel dissolves all over a ferrite base and contributing it to strengthening of a base, in order that a part may deposit the intermetallic compound of NiAl under coexistence with aluminum and may raise the hardness of a base material, it is an element indispensable to this alloy. although at least 2% or more of nickel is required in order to acquire the above-mentioned effect, if the amount of nickel is made to contain 15% or more conversely, since an austenite phase will generate and the intensity of a base material will fall extremely all over a base, let the range of nickel be less than 15% of not less than 2% The desirable range of nickel is less than 15% 5% or more. The still more desirable range is 7 - 13%.

[0015] Cr is an element important simultaneously with the effect of making the coat to which the adhesion force with member makes the oxide of uniform aluminum a subject strongly forming when stabilizing the ferrite phase of a base material in the Fe-nickel-Cr-aluminum system ferrite alloy of this invention. the above-mentioned effect is acquired being alike -- although 15% or more of Cr is required, if contained 20% or more conversely, since the fluidity and plastic-working nature of an alloy fall remarkably, the range of Cr will be made into less than 20% 15% or more The desirable range of Cr is 16 - 19.5%.

[0016] while aluminum deposits NiAl all over a ferrite base and raises the hardness of a base material under coexistence with nickel -- oxidation treatment after fabricating to a member -- a member -- it is an indispensable element, in order to make the coat which makes the oxide of uniform aluminum a subject form in a front face and to improve the erosion-proof nature to a metal molten metal, and the abrasion resistance of the sliding section although is required to add 2% or more of aluminum in order to acquire the above-mentioned effect, if contained exceeding 8% the toughness and plastic-working nature of an alloy will make the range of the well aluminum which falls remarkably 2 - 8% The desirable range of aluminum is 4 - 8%. The still more desirable range is 4.5 - 7%.

[0017] Ti, Zr, Hf, V, Nb, Y, and rapid eye movement -- a member -- oxidation treatment carried out after fabrication a member -- an oxide particle is formed in the interior side of a ferrite base material directly under a coat which makes a subject the oxide of the aluminum formed in a front face, and since it has the effect which raises remarkably the adhesion of the coat which makes an aluminum oxide a subject, one sort or two sorts or more are added although at least 0.05% or more needs to be added of independent or composite in order to acquire this effect, if it adds too much an oxide particle will turn big and rough conversely, and membranous adhesion will be fallen -- making -- a sake -- o sort of Ti, Zr, Hf, V, Nb, Y, and rapid eye movement, or two sorts or more -- 0.05 - 1.0% -- carrying out .

[0018] Although it is not necessary to necessarily add, by dissolving and carrying out solid solution strengthening in a base material, W, Mo, and Co have the effect which raises a high temperature strength further, and are added if needed. if 2% is exceeded 0.2% although addition of a not less is required in order to acquire the above-mentioned effect, the deformation resistance in an elevated temperature will increase and hot-working nature will get worse remarkably Moreover, since the above-mentioned element is expensive, it becomes disadvantageous also in cost. Therefore, one sort of W, Mo, and Co which are added if needed, or two sorts or more are made into 0.2 - 2.0%.

[0019] It dissolves, and after ingot making of the manufacture method of this invention alloy is carried out, it perform plastic working of hot working or hot working, and cold working, and annealing, machines if needed further, is fabricated in a predetermined configuration, and let it be a member. Then, heating maintenance of this member is carried out at the temperature of 800-1300 degrees C among an oxidizing atmosphere, and after making the coat which makes the oxide of aluminum a subject form in a front face, it cools at air cooling or the speed beyond it. In addition can serve as the annealing processing carried out after plastic working of this invention alloy with oxidation treatment and it can be carried out. And according to this invention alloy and its manufacture method, since the hardening tempering processing needed with steel with the conventional tool steel base is not needed, either, it is also the feature that a process can be shortened sharply. In this invention, it is an important means to perform this oxidation treatment in order to raise the erosion-proof nature of this invention alloy, and abrasion resistance. While the ferrite base of a base material stiffens at the temperature which the thickness of the coat which oxidation-treatment temperature makes

demonstrate the above-mentioned effect at less than 800 degrees C is not obtained, and exceeds 1300 degrees C at the time, the coat which makes the oxide of the aluminum formed a subject becomes easy to exfoliate. Therefore, oxidation-treatment temperature is made into 800-1300 degrees C.

[0020] Moreover, if the cooling rate after oxidation treatment becomes slow too much, since NiAl in a ferrite base will turn big and rough and base material hardness will fall, it is good to cool as early as possible above air cooling. In the case of a simple configuration, water cooling and oil quenching may be used. However, casting -- public funds -- type etc. has many things of a complicated configuration and extreme quenching, such as water cooling and oil quenching causes [of the coat which makes a subject the oxide of the aluminum which the deformation and the shocking thermal stress by heat treatment distortion of a base material generated and formed] ablation in this case. Therefore, in the case of the complicated member of a configuration, it is good to cool radiationally or air-blast cool cooling after oxidation treatment.

[0021] Furthermore, when formation of the coat which makes a subject the oxide of the aluminum of thickness which can be enough borne to the erosion of a metal molten metal, and wear-resistant improvement are taken into consideration, after a member reaches predetermined temperature, it is desirable [the oxidation-treatment time for making the oxide of aluminum form on the surface of a member], although it is good to set up suitably if needed with the use and size of a member to make it hold for 5 to 20 hours.

[0022]

[Example] this invention is explained based on an example below.

(Example 1) The material which consists of composition of No.1-24 and No.30-34 shown in Table 1 was dissolved by the vacuum induction melting furnace. After it performed hot forging, and the cross section processed it into the square bar which is 40mmx15mm and performed annealing processing, the obtained ingot was processed into the predetermined test piece, and was taken as the test specimen. After performing annealing processing for the ingot obtained by dissolving again about the thing in which the processability of an alloy was bad and hot forging was impossible at this time, the predetermined test piece was cut down. Moreover, about the conventional alloy (61 about SKD) of No.40, it dissolved into the atmosphere, and after the cross section used the obtained ingot as the square bar which is 40mmx15mm with hot forging, annealing processing was performed and it was processed into the predetermined test piece after that. The characteristic test shown below was performed to the above-mentioned test specimen.

[0023] About No.1-24 and No.30-34, each characteristic test took out quickly the test piece cut down from each obtained test specimen from the furnace after heating maintenance all over the furnace of an oxidizing atmosphere for 1150 degrees C and 15 hours, cooled it with the average cooling rate of about 100 degrees C/second to ordinary temperature, and after it performed oxidation treatment, it examined. Moreover, about SKD61 which is the conventional alloy of No.40, after changing and adjusting tempering temperature to 600-650 degrees C so that hardness may be continuously performed 1030-degree C oil quenching and set to 40HRC(s) in the cut-down test piece, it examined by performing surface treatment shown in Table 2. In addition, about evaluation of plastic-working nature presupposed that forging of the alloy which deformability is remarkably inferior at the time of hot forging, and a large crack produces is impossible, and deformability evaluated the good alloy as forging being possible.

[0024]

[Table 1]



合金 No.	化 学 組 成 (wt%)																備考
	C	Si	Mn	Ni	Cr	W	Mo	Co	Al	Ti	Zr	Hf	V	Nb	Y	REX	F <sub>0</sub>
1	0.006	0.13	1.21	11.3	18.8	0.13	0.51	—	5.2	0.31	—	0.18	—	—	0.11	—	推
2	0.005	0.92	1.42	7.8	18.9	0.62	1.02	—	5.1	—	—	0.21	—	—	0.05	0.08	#
3	0.002	0.09	1.21	9.8	17.6	—	0.21	—	5.3	—	—	0.19	—	—	—	0.06	#
4	0.008	0.56	1.32	8.8	18.2	—	—	1.32	5.8	—	0.18	—	0.11	—	—	0.05	#
5	0.003	0.10	0.64	10.3	18.3	0.55	—	0.33	4.2	0.16	0.22	0.28	—	—	0.15	—	#
6	0.002	0.81	0.23	11.6	19.0	—	0.63	—	6.8	—	0.13	0.22	—	0.12	—	—	#
7	0.009	1.32	0.18	14.1	18.3	—	—	—	5.0	—	—	—	—	—	—	0.18	#
8	0.028	0.07	0.16	10.1	17.4	—	0.33	0.46	5.8	—	—	0.22	—	—	—	—	#
9	0.007	0.21	0.32	12.3	19.1	—	1.02	0.57	6.2	—	—	—	—	—	0.19	—	#
10	0.005	0.04	1.64	6.7	15.7	1.22	—	—	4.7	0.46	0.20	—	—	—	0.12	—	#
11	0.004	0.09	1.72	8.8	17.0	—	—	—	4.9	—	—	—	—	0.11	—	0.23	#
12	0.007	0.09	1.81	7.8	17.6	—	—	—	5.3	—	—	—	—	0.21	—	—	#
13	0.005	0.07	1.13	10.3	18.9	—	—	—	5.1	0.33	—	—	—	—	0.12	—	#
14	0.004	0.07	1.41	9.8	17.2	—	—	—	6.1	0.21	—	—	—	—	—	—	#
15	0.005	0.05	0.25	10.0	18.9	—	—	—	6.6	—	0.15	—	0.12	—	—	—	#
16	0.003	0.05	1.35	9.9	17.7	—	—	—	5.3	—	—	—	0.32	—	—	—	#
17	0.006	1.21	1.57	8.2	16.6	0.65	—	—	4.8	—	0.17	—	—	0.21	0.03	0.07	#
18	0.003	0.07	1.02	10.3	18.2	—	—	—	5.3	—	0.22	—	—	—	—	—	#
19	0.007	0.05	0.42	7.0	15.3	0.23	0.16	—	4.7	0.33	0.18	0.22	—	—	0.10	0.05	#
20	0.004	1.13	1.12	12.4	17.8	0.38	0.86	0.52	7.8	—	—	—	—	—	0.08	0.08	#
21	0.003	0.06	0.05	10.1	18.3	—	—	—	5.3	—	0.20	—	—	—	—	—	#
22	0.004	0.03	0.02	3.8	18.6	—	—	—	5.3	—	0.20	0.10	—	—	—	0.05	#
23	0.006	0.82	0.07	3.2	17.3	—	—	—	4.7	—	0.20	—	—	—	—	—	#
24	0.003	0.05	0.02	2.8	15.8	—	0.50	—	5.3	0.18	—	0.10	—	0.10	—	0.05	#
30	0.006	0.07	0.02	20.6	33.1	—	—	—	5.2	—	0.22	—	—	—	—	—	#
31	0.005	0.07	0.24	21.2	20.6	—	0.21	—	5.3	0.15	0.18	—	0.11	—	—	—	#
32	0.008	0.65	1.01	10.6	30.4	0.62	—	—	3.2	0.32	0.14	—	—	—	—	0.08	#
33	0.004	1.89	0.01	20.3	34.2	0.11	—	0.32	4.9	—	0.21	—	—	0.10	—	0.05	#
34	0.235	0.61	1.20	12.3	18.3	—	0.32	0.11	5.1	—	0.15	0.05	—	—	—	—	#
40	0.39	0.80	0.41	—	5.20	—	1.42	—	—	—	—	—	0.63	—	—	—	#

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[0025]  
[Table 2]

供試材 No.	処理方法	処理層もしくは 処理条件
40-1	プラズマ化学蒸着法 (PCVD)	Al <sub>2</sub> O <sub>3</sub>
40-2	プラズマ化学蒸着法 (PCVD)	TiN
40-3	大気溶射法	WC-Co
40-4	大気溶射法	TiB <sub>2</sub>
40-5	ガス窒化法	520℃×10時間
40-6	塩浴浸硫窒化法	580℃×15時間

[0026] (1) Hot forging was performed about the ingot of No.1-24 and No.30-34 obtained by the processability evaluation vacuum induction melting furnace, and the propriety of the forging in that case estimated processability. (2) Abrasion loss abrasion loss carried out fixed time sliding of the test piece of 8mm round-head x25mm length by non-lubrication, forcing the end face of a test piece on the flat surface of the partner material of a tabular, and measu abrasion loss from the amount of losses of the test piece after an examination. In addition, SCN415 (annealed materi is used for partner material, and 10 m/min and test time moved the load reciprocally by 30kgf(s), and made sliding speed move reciprocally in 1.5 hours.

(3) The molten-metal-proof erosion \*\*\*\* aluminum erosion examination was immersed in the test piece for 3 hours into the 750-degree C molten metal of aluminum containing alloy AC4CH, and compared the erosion-proof nature b the weight ratio before and behind the examination of a test piece. About the zinc-proof erosion examination, the tes piece was immersed into the 600-degree C molten metal of a zinc alloy ZAC2 for 20 hours, and the erosion nature w evaluated by the same method as an aluminum-proof erosion examination. The above result and the internal hardnes measurement result of each test piece after oxidation treatment are shown in Table 3, respectively.

[0027]

[Table 3]

合金 No.	塑性加工性評価 鍛造の可否 (注)	内部硬さ (HV)	摩耗量 ( $\times 10^{-4}$ g)	耐Al溶損性 減量率 (%)	耐Zn溶損性 減量率 (%)	備考
1	○	456	3	0.1	0	本発明合金
2	○	436	10	0.3	0	
3	○	450	3	0.2	0	
4	○	438	9	0.9	0	
5	○	466	3	0.2	0	
6	○	461	8	0.3	0	
7	○	472	15	0.1	0	
8	○	449	3	0.4	0	
	○	452	3	0.2	0	
10	○	430	3	0.7	0	
11	○	460	3	0.2	0	
12	○	449	3	0.1	0	
13	○	466	3	0.2	0	
14	○	443	3	0.1	0	
15	○	442	3	0.2	0	
16	○	461	3	0.3	0	
17	○	438	13	0.9	0	
18	○	467	3	0.1	0	
19	○	432	3	0.1	0	
20	○	463	13	0.5	0	
21	○	452	3	0.1	0	
22	○	421	3	0.1	0	
23	○	419	8	0.3	0	
24	○	413	3	0.2	0	
30	×	452	3	6.8	0	比較合金
31	○	245	134	1.6	0	
32	×	280	148	8.7	0.01	
33	×	455	64	20.6	1.72	
34	○	450	280	65.2	3.10	
40-1 PCVD (Al <sub>2</sub> O <sub>3</sub> )	—	382	4	9.6	0.01	従来合金
40-2 PCV (TiN)	—	388	4	10.1	0.01	
40-3 溶射 (WC-CO)	—	395	3	8.8	0.02	
40-4 溶射 (TiB <sub>2</sub> )	—	396	4	15.3	0	
40-5 ガス酸化	—	396	8	12.7	0.01	
4-6 塩浴深炭素化	—	392	14	5.5	0.01	

(注) ○…鍛造可能 ×…鍛造不可能

[0028] As shown in Table 3, this invention alloy is very excellent in processability, and can perform hot forging easi on the other hand -- although No.30 which added the inside Cr of a comparison alloy so much, and 32 and 33 had ve

bad plastic-working nature, many cracks occurred under hot forging and in the ingot and it was not able to forge -- the amount of Cr(s) -- comparatively -- lowering -- coming out -- certain No. -- 31 and 34 do not have a problem in the processability, and hot forging was able to be performed easily moreover -- even if it compares the internal hardness after oxidation treatment of this invention alloy with 380 - 400HV of an alloy SKD61 conventionally -- hardness -- 410HV - 460HV -- it is -- casting -- public funds -- it can be equal to the use as type or a \*\*\*\*\* instrument enough Although the alloy of No.31 is excellent in processability, since the amount of nickel separates from the range of the alloy of this invention, it turns out that internal hardness falls remarkably. [0029] although the coat which makes the oxide of surface aluminum a subject when the addition of Si increases becomes porous [-like ], abrasion loss increases the abrasion loss of this invention alloy a little and the abrasion resistance falls a little -- any -- the former -- the abrasion loss of an alloy -- comparing -- almost -- this level -- or the abrasion resistance beyond it is shown and it is good however, the abrasion loss of a comparison alloy -- No. -- since the shortage of hardness of a base material and the adhesion of the coat which makes the oxide of aluminum a subject are insufficient about 31 and 32, and since the compactness of the coat which makes the oxide of aluminum a subject by too much addition of Si about No.33 fell extremely, during the abrasion test, ablation of a coat arose and abrasion loss increased Since the coat which makes the oxide of aluminum a subject during oxidation treatment by too much addition of C was destroyed, comparison alloy No.34 are considered that the wear-resistant improvement effect by the coat was not acquired.

[0030] Next, it turns out that the test piece in which the coat which performs oxidation treatment into this invention alloy, and makes the oxide of aluminum a subject about the molten-metal-proof erosion nature of each test specimen was made to form has very high erosion-proof nature to an aluminum containing alloy and a zinc alloy, and it excels very much even if it compares with what performed salt bath nitrosulphurizing to SKD61 of conventional alloy No.4 6. On the other hand, with the comparison alloy, since the coat to which comparison alloy No.34 of this invention all and equivalent level make the oxide of aluminum a subject during oxidation treatment by too much addition of C was destroyed for processability and internal hardness, the protective effect of a coat was not obtained but the molten-metal-proof erosion nature fell remarkably. Moreover, since hot forging was impossible, although comparison alloy No.30 which processed the test piece and performed oxidation treatment from the ingot were equivalent to this invention alloy about internal hardness and abrasion resistance, from the defect in the test piece by poor solidification, molten metal permeated and the erosion occurred.

[0031] this invention alloy is oxidation treatment. Although erosion-proof nature is raised by the coat which makes a subject the oxide of the aluminum which makes the oxide of aluminum a subject being formed in a front face, and intercepting a base material from molten metal It was admitted that molten metal permeated from the crack in the film imagined to be what conventional alloy No.40-1 which covered the alumina of this component with the plasma-chemistry vacuum deposition mostly with the coat generated in the covering process, SKD61 and molten metal of a base material reacted, and the erosion had occurred. In addition, in this example, although the result of the erosion-proof examination to an aluminum containing alloy and a zinc alloy was shown, generally erosions, such as metal mold by molten metal, advance by formation of a compound by contact to molten metal and the metal which are base materials, such as metal mold. therefore, casting of this invention -- public funds -- it is checked that the erosion-proof nature to the alloy of a copper system, other molten metal, for example, iron system, is excellent similarly to an aluminum system or a zinc system if [ material / of type or a \*\*\*\*\* instrument ]

[0032]

[Effect of the Invention] As mentioned above, the Fe-nickel-Cr-aluminum system ferrite alloy of this invention, even if it makes high intensity and the coat which makes the oxide of the aluminum of high adhesion a subject form in a base material front face and does not need special surface treatment by using oxidation treatment together in consideration of the balance on a chemical composition -- molten-metal-proof erosion nature and wear-resistant improvement are possible -- becoming -- casting -- public funds -- metal molten-metal contact members, such as type, and abrasion resistance -- the life of a member can be improved sharply Moreover, SKD61 currently used, [ than before ] [ more ] predetermined member -- after processing it to a configuration, and performing hardening and heat treatment of annealing, surface treatment, such as nitriding treatment, is performed further, this invention article does not need to perform complicated surface treatment or complicated heat treatment after processing to having had to raise erosion-proof nature and abrasion resistance, and since the target property is acquired only by performing easy oxidation treatment, shortening of the manufacturing process of a member and curtailment of a manufacturing cost become sharply possible

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TECHNICAL FIELD

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[The technical field to which invention belongs] this invention relates to the Fe-nickel-Cr-aluminum system ferrite alloy used as metal molten-metal contact members, such as metal mold, and the part, nesting, and a wear-resistant member, and its manufacture method.

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PRIOR ART

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[Description of the Prior Art] Usually, in case the molten metal of metallic materials, such as an alloy which makes a subject Fe, nickel, Co, aluminum, Zn, Cu, Mg, or these metals, is cast, steel, such as a die steel between heat, high-speed steel, and stainless steel, has been conventionally used for metal molten-metal contact members, such as metal mold. In the portion in which a metal molten metal contacts the above-mentioned ferrous material, these ferrous materials carried out the erosion by the metal molten metal, and increased the iron content in a metal molten metal, and there was a fault in which the quality of casting parts is reduced. Furthermore, erosions, such as these metal mold, produced operation top various un-arranging, such as the poor skin, the cast, and metal mold of a cast welding, and producing a poor mold-release characteristic, and had the problem from which the function of a member falls at an early stage, and serves as a short life.

[0003] In order to solve these troubles, perform surface treatment, such as carburization and nitriding, to the front face of a member which manufactured from the ferrous material conventionally. The proposal which covers a front face with the physical vapor deposition represented by a plasma-chemistry vacuum deposition, the sputtering method, etc a nitride besides [ a hard layer is made to form in ] a method, carbide, a boride (for example, TiN, TiC, BN, SiC, Si<sub>3</sub>N<sub>4</sub>, TiB<sub>2</sub>, aluminum 2O<sub>3</sub>), etc. or the welding method, a shrinkage fit method, etc. is made (JP,56-111560,A, JP,59-21416,A, JP,59-33128,A, JP,60-178017,A, JP,61-33734,A). Moreover, on the other hand, a part of material of the ceramic system which hardly reacts to molten metal, W alloy which cannot start an erosion easily, Mo alloy, etc. are used.

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**EFFECT OF THE INVENTION**

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[Effect of the Invention] As mentioned above, the Fe-nickel-Cr-aluminum system ferrite alloy of this invention, even it makes high intensity and the coat which makes the oxide of the aluminum of high adhesion a subject form in a basic material front face and does not need special surface treatment by using oxidation treatment together in consideration of the balance on a chemical composition -- molten-metal-proof erosion nature and wear-resistant improvement are possible -- becoming -- casting -- public funds -- metal molten-metal contact members, such as type, and abrasion resistance -- the life of a member can be improved sharply. Moreover, SKD61 currently used, [ than before ] [ more ] predetermined member -- after processing it to a configuration, and performing hardening and heat treatment of annealing, surface treatment, such as nitriding treatment, is performed further, this invention article does not need to perform complicated surface treatment or complicated heat treatment after processing to having had to raise erosion-proof nature and abrasion resistance, and since the target property is acquired only by performing easy oxidation treatment, shortening of the manufacturing process of a member and curtailment of a manufacturing cost become sharply possible.

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**TECHNICAL PROBLEM**

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[Problem(s) to be Solved by the Invention] Since a deep processing layer is not only obtained by the member manufactured from the above-mentioned ferrous material, but carburization and the nitrided surface treatment layer a diffusion process and there is no problem of exfoliation in it, it is mostly used in combination with the quality of the material developed on the assumption that these processings were carried out to it. Moreover, it is mentioned that the greatest advantage of such surface treatment is very cheap. However, compared with a conventional aluminum containing alloy and a conventional zinc alloy, use of the aluminum containing alloy of a high-melting point or a zinc alloy has increased by high intensity-ization of casting parts in recent years as a cast material.

[0005] therefore, the metal mold carried out from the former -- C in a surface treatment layer and N carried out back diffusion of gas of what performed carburization or nitriding treatment to the surface section into the metal molten metal by the temperature up at the time of work, and the problem which the fall of an original erosion-proof nature function produces came out of it. Moreover, there was a fault which the phenomenon of expansion of volume arising since a detailed crack is accepted, a molten metal permeates by making this crack into a path, it reacts with the iron in the base material directly under an enveloping layer and an alloy is formed into an enveloping layer when covering a using the hard matter of a ceramic system by the chemical vapor deposition and the physical vapor deposition, consequently making an enveloping layer exfoliating generates. Furthermore, the material of a ceramic system, W alloy, and Mo alloy were very expensive, and when used as nesting, they were neither the various problems by the difference of a coefficient of thermal expansion with a surrounding ferrous material being large, nor the thing which breaks, and there is which insufficient problem of the intensity to a chip etc., toughness, and a thermal shock resistance and can not necessarily be satisfied.

[0006] The purpose of this invention is offering the Fe-nickel-Cr-aluminum system ferrite alloy which is excellent in the erosion-proof nature and abrasion resistance based on the new view which solves the problem of these above, and has very good processability, and its manufacture method.

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## MEANS

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[Means for Solving the Problem] Conventionally, it is known well that the quality of the material of a ceramic system will hardly react with molten metal. However, when the quality of the material of a SERAMMIKUSU system is applied to metal mold etc., as mentioned above, there are various troubles and the present condition is being unable to desire improvement in the mold life beyond carburization and the surface treatment using diffusion by nitriding, and cost-predominance. Then, the artificer used the ferrous material for the base material, is the composition which may make a front face generate the coat which makes a subject the aluminum oxide which is oxide system ceramics by carrying out high temperature oxidation of this, and raised molten-metal-proof erosion nature and abrasion resistance and considered proper composition which is of the same grade as the conventional metal mold or a wear-resistant member about processability. Consequently, an alloy new as basic composition is found out for an Fe-Cr-nickel-aluminum system ferrite alloy. While this invention alloy consists of a chemical composition shown below and having the outstanding plastic-working nature, it is one of the big features to make erosion-proof nature and the coat which makes a subject the oxide of the aluminum which reached or was excellent in abrasion resistance form in the work face of a member at least by oxidation treatment after fabrication.

[0008] The 1st invention of this invention by the weight ratio Namely, C:0.05% or less, less than [ Si:2% ], Mn: Less than [ 2% ], less than [ more than nickel:2%15% ], less than [ more than Cr:15%20% ], aluminum: The remainder is Fe-nickel-Cr-aluminum system ferrite alloy substantially characterized by the bird clapper from an unescapable impurity at Fe row one sort of 2-8%, and Ti, Zr, Hf, V, Nb, Y and rapid eye movement, or : [ two or more sorts of ] 0.05 to 1.0%.

[0009] The 2nd invention by the weight ratio Moreover, C:0.05% or less, less than [ Si:2% ], less than [ Mn:2% ], nickel: Less than [ more than 2%15% ], less than [ more than Cr:15%20% ], aluminum:2-8%, Ti, Zr, Hf, V, Nb, Y, and one sort or : [ two or more sorts of ] 0.05 - 1.0% of rapid eye movement Furthermore, it is the Fe-nickel-Cr-aluminum system ferrite alloy with which the remainder is substantially characterized by the bird clapper from an unescapable impurity at Fe row one sort of W, Mo, and Co, or : [ two or more sorts of ] 0.2 to 2.0%. This invention is characterized by adding one sort of W, Mo, and Co, or two sorts or more in 0.2 - 2.0% of range further to the 1st invention.

[0010] the inside of a 800-1300 degrees C [ after the 3rd invention furthermore fabricates the alloy material which consists of composition of the 1st invention or the 2nd invention in a predetermined configuration about the oxide skin forming method of the above-mentioned invention alloy ] oxidizing atmosphere -- heating maintenance -- carrying out a member -- after making the coat which makes the oxide of aluminum a subject form in a front face, it is the manufacture method of the Fe-nickel-Cr-aluminum system ferrite alloy characterized by to cool the speed more than a cooling

[0011]

[Embodiments of the Invention] The reason for limitation of the chemical composition of an Fe-nickel-Cr-aluminum system ferrite alloy and operation concerning this invention are described below.

[0012] In order that C may combine with Cr contained into this invention alloy, Ti, Zr, Hf, V, Nb, W, Mo which are added alternatively, etc., may form carbide and may reduce the addition effect of these elements, its method of a low desirable. Moreover, if the content of C increases, it will also become the cause that the coat which makes a subject the oxide of the aluminum formed during oxidation treatment of a member by CO<sub>2</sub> gas which occurs from a base material surface is destroyed. However, although the upper limit is made into 0.05% since C is mixed from a raw material and costs increase also to decarbonization refinement, it is 0.01% or less desirably.

[0013] Si is a very effective element, in order to raise the fluidity nature of this alloy and to manufacture a healthy in

at the time of casting in manufacture of the Fe-nickel-Cr-aluminum system ferrite alloy of this invention. A part exists as oxides, such as SiO<sub>2</sub>, in the coat which makes a subject the oxide of the aluminum made to form in a front face. moreover, the member which consists of this invention alloy -- In order to make porous moderately the coat which makes a subject the oxide of the aluminum which the compactness of a coat is reduced and is formed in a front face high-temperature-oxidation processing, when it is used as a die-casting die, the degassing nature and the mold-release characteristic of the gas which occurs from molten metal are improved at the time of casting -- making -- moreover, low pressure casting -- public funds -- the case where it is used as type -- metal mold -- the peeling resistance of the paint applied to a front face is raised however, ablation of the coat to which the compactness of the coat which make the oxide of aluminum a subject will fall remarkably, and will make the oxide of aluminum a subject during use if contained exceeding 2% -- being generated -- casting -- public funds -- since it stops being suitable for the use as type the upper limit of Si is made into 2% The desirable range of Si is 0.3 - 1.5%.

[0014] Mn acts as deoxidation and a devulcanizing agent, and it is added in order to raise the cleanliness of an alloy. However, since hot-working nature will fall if it adds exceeding 2%, the upper limit of Mn is made into 2% or less. While nickel dissolves all over a ferrite base and contributing it to strengthening of a base, in order that a part may deposit the intermetallic compound of NiAl under coexistence with aluminum and may raise the hardness of a base material, it is an element indispensable to this alloy. although at least 2% or more of nickel is required in order to acquire the above-mentioned effect, if the amount of nickel is made to contain 15% or more conversely, since an austenite phase will generate and the intensity of a base material will fall extremely all over a base, let the range of nickel be less than 15% or not less than 2% The desirable range of nickel is less than 15% 5% or more. The still more desirable range is 7 - 13%.

[0015] Cr is an element important simultaneously with the effect of making the coat to which the adhesion force with member makes the oxide of uniform aluminum a subject strongly forming when stabilizing the ferrite phase of a base material in the Fe-nickel-Cr-aluminum system ferrite alloy of this invention. the above-mentioned effect is acquired being alike -- although 15% or more of Cr is required, if contained 20% or more conversely, since the fluidity and plastic-working nature of an alloy fall remarkably, the range of Cr will be made into less than 20% 15% or more The desirable range of Cr is 16 - 19.5%.

[0016] while aluminum deposits NiAl all over a ferrite base and raises the hardness of a base material under coexistence with nickel -- oxidation treatment after fabricating to a member -- a member -- it is an indispensable element, in order to make the coat which makes the oxide of uniform aluminum a subject form in a front face and to improve the erosion-proof nature to a metal molten metal, and the abrasion resistance of the sliding section although is required to add 2% or more of aluminum in order to acquire the above-mentioned effect, if contained exceeding 8% the toughness and plastic-working nature of an alloy will make the range of the well aluminum which falls remarkably 2 - 8% The desirable range of aluminum is 4 - 8%. The still more desirable range is 4.5 - 7%.

[0017] Ti, Zr, Hf, V, Nb, Y, and REM -- a member -- oxidation treatment carried out after fabrication -- a member -- oxide particle is formed in the interior side of a ferrite base material directly under a coat which makes a subject the oxide of the aluminum formed in a front face, and since it has the effect which raises remarkably the adhesion of the coat which makes an aluminum oxide a subject, one sort or two sorts or more are added although at least 0.05% or more needs to be added of independent or composite in order to acquire this effect, if it adds too much, an oxide particle will turn big and rough conversely, and membranous adhesion will be fallen -- making -- a sake -- one sort of Ti, Zr, Hf, V, Nb, Y, and REM, or two sorts or more -- 0.05 - 1.0% -- carrying out .

[0018] Although it is not necessary to necessarily add, by dissolving and carrying out solid solution strengthening in a base material, W, Mo, and Co have the effect which raises a high temperature strength further, and are added if needed. if 2% is exceeded 0.2% although addition of a not less is required in order to acquire the above-mentioned effect, the deformation resistance in an elevated temperature will increase and hot-working nature will get worse remarkably Moreover, since the above-mentioned element is expensive, it becomes disadvantageous also in cost. Therefore, one sort of W, Mo, and Co which are added if needed, or two sorts or more are made into 0.2 - 2.0%.

[0019] It dissolves, and after ingot making of the manufacture method of this invention alloy is carried out, it performs plastic working of hot working or hot working, and cold working, and annealing, machines if needed further, is fabricated in a predetermined configuration, and let it be a member. Then, heating maintenance of this member is carried out at the temperature of 800-1300 degrees C among an oxidizing atmosphere, and after making the coat which makes the oxide of aluminum a subject form in a front face, it cools at air cooling or the speed beyond it. In addition can serve as the annealing processing carried out after plastic working of this invention alloy with oxidation treatment

and it can be carried out. And according to this invention alloy and its manufacture method, since the hardening tempering processing needed with steel with the conventional tool steel base is not needed, either, it is also the feature that a process can be shortened sharply. In this invention, it is an important means to perform this oxidation treatment in order to raise the erosion-proof nature of this invention alloy, and abrasion resistance. While the ferrite base of a material stiffens at the temperature which the thickness of the coat which oxidation-treatment temperature makes demonstrate the above-mentioned effect at less than 800 degrees C is not obtained, and exceeds 1300 degrees C at the time, the coat which makes the oxide of the aluminum formed a subject becomes easy to exfoliate. Therefore, oxidation-treatment temperature is made into 800-1300 degrees C.

[0020] Moreover, if the cooling rate after oxidation treatment becomes slow too much, since NiAl in a ferrite base will turn big and rough and base material hardness will fall, it is good to cool as early as possible above air cooling. In the case of a simple configuration, water cooling and oil quenching may be used. However, casting -- public funds -- type etc. has many things of a complicated configuration and extreme quenching, such as water cooling and oil quenching causes [of the coat which makes a subject the oxide of the aluminum which the deformation and the shocking thermal stress by heat treatment distortion of a base material generated and formed] ablation in this case. Therefore, in the case of the complicated member of a configuration, it is good to cool radiationally or air-blast cool cooling after oxidation treatment.

[0021] Furthermore, when formation of the coat which makes a subject the oxide of the aluminum of thickness which can be enough borne to the erosion of a metal molten metal, and wear-resistant improvement are taken into consideration, after a member reaches predetermined temperature, it is desirable [the oxidation-treatment time for making the oxide of aluminum form on the surface of a member], although it is good to set up suitably if needed with the use and size of a member to make it hold for 5 to 20 hours.

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EXAMPLE

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[Example] this invention is explained based on an example below.

(Example 1) The material which consists of composition of No.1-24 and No.30-34 shown in Table 1 was dissolved by the vacuum induction melting furnace. After it performed hot forging, and the cross section processed it into the square bar which is 40mmx15mm and performed annealing processing, the obtained ingot was processed into the predetermined test piece, and was taken as the test specimen. After performing annealing processing for the ingot obtained by dissolving again about the thing in which the processability of an alloy was bad and hot forging was impossible at this time, the predetermined test piece was cut down. Moreover, about the conventional alloy (61 about SKD) of No.40, it dissolved into the atmosphere, and after the cross section used the obtained ingot as the square bar which is 40mmx15mm with hot forging, annealing processing was performed and it was processed into the predetermined test piece after that. The characteristic test shown below was performed to the above-mentioned test specimen.

[0023] About No.1-24 and No.30-34, each characteristic test took out quickly the test piece cut down from each obtained test specimen from the furnace after heating maintenance all over the furnace of an oxidizing atmosphere for 1150 degrees C and 15 hours, cooled it with the average cooling rate of about 100 degrees C/second to ordinary temperature, and after it performed oxidation treatment, it examined. Moreover, about SKD61 which is the conventional alloy of No.40, after changing and adjusting tempering temperature to 600-650 degrees C so that harden may be continuously performed 1030-degree C oil quenching and set to 40HRC(s) in the cut-down test piece, it examined by performing surface treatment shown in Table 2. In addition, about evaluation of plastic-working nature presupposed that forging of the alloy which deformability is remarkably inferior at the time of hot forging, and a large crack produces is impossible, and deformability evaluated the good alloy as forging being possible.

[0024]

[Table 1]

合金 No.	化 学 組 成 (wt%)																	備考
	C	Si	Mn	Ni	Cr	W	Mo	Co	Al	Ti	Zr	Hf	V	Nb	Y	REY	Fa	
1	0.006	0.13	1.21	11.3	18.8	0.13	0.51	—	5.2	0.31	—	0.18	—	—	0.11	—	預	
2	0.005	0.92	1.42	7.8	18.9	0.62	1.02	—	5.1	—	—	0.21	—	—	0.05	0.08	#	
3	0.002	0.09	1.21	9.8	17.9	—	0.21	—	5.3	—	—	0.19	—	—	—	0.08	#	
4	0.008	0.58	1.32	8.8	18.2	—	—	1.32	5.8	—	0.18	—	0.11	—	—	0.05	#	
5	0.003	0.10	0.64	10.3	18.3	0.55	—	0.33	4.2	0.16	0.22	0.28	—	—	0.15	—	#	
6	0.002	0.81	0.23	11.6	19.0	—	0.63	—	8.8	—	0.13	0.22	—	0.12	—	—	#	
7	0.009	1.32	0.18	14.1	19.3	—	—	—	5.0	—	—	—	—	—	—	0.18	#	
8	0.028	0.07	0.18	10.1	17.4	—	0.38	0.48	5.8	—	—	0.22	—	—	—	—	#	
9	0.007	0.21	0.32	12.3	19.1	—	1.02	0.57	8.2	—	—	—	—	—	0.19	—	#	
10	0.005	0.04	1.64	8.7	15.7	1.22	—	—	4.7	0.46	0.20	—	—	—	0.12	—	#	
11	0.004	0.09	1.72	8.8	17.0	—	—	—	4.9	—	—	—	—	0.11	—	0.23	#	本発明合金
12	0.007	0.09	1.31	7.8	17.6	—	—	—	5.3	—	—	—	—	0.21	—	—	#	
13	0.005	0.07	1.13	10.3	18.9	—	—	—	5.1	0.33	—	—	—	—	0.12	—	#	
14	0.004	0.07	1.41	9.8	17.2	—	—	—	6.1	0.21	—	—	—	—	—	—	#	
15	0.005	0.05	0.25	10.0	18.9	—	—	—	6.6	—	0.15	—	0.12	—	—	—	#	
16	0.003	0.05	1.35	9.9	17.7	—	—	—	5.3	—	—	—	0.32	—	—	—	#	
17	0.008	1.21	1.57	8.2	16.6	0.65	—	—	4.8	—	0.17	—	—	0.21	0.03	0.07	#	
18	0.003	0.07	1.02	10.3	18.2	—	—	—	5.3	—	0.22	—	—	—	—	—	#	
19	0.007	0.05	0.42	7.0	15.3	0.23	0.16	—	4.7	0.33	0.18	0.22	—	—	0.10	0.05	#	
20	0.004	1.13	1.12	12.4	17.8	0.38	0.66	0.52	7.8	—	—	—	—	—	0.08	0.09	#	
21	0.003	0.05	0.05	10.1	18.3	—	—	—	5.3	—	0.20	—	—	—	—	—	#	
22	0.004	0.03	0.02	3.8	18.6	—	—	—	5.3	—	0.20	0.10	—	—	—	0.05	#	
23	0.008	0.82	0.07	3.2	17.3	—	—	—	4.7	—	0.20	—	—	—	—	—	#	
24	0.003	0.05	0.02	2.8	15.8	—	0.50	—	5.3	0.18	—	0.10	—	0.10	—	0.05	#	
30	0.008	0.07	0.02	20.6	33.1	—	—	—	5.2	—	0.22	—	—	—	—	—	#	
31	0.005	0.07	0.24	21.2	20.6	—	0.21	—	5.3	0.15	0.19	—	0.11	—	—	—	#	
32	0.008	0.85	1.01	10.6	30.4	0.62	—	—	3.2	0.32	0.14	—	—	—	—	0.08	#	比較合金
33	0.004	1.89	0.01	20.3	34.2	0.11	—	0.32	4.9	—	0.21	—	—	0.10	—	0.05	#	
34	0.235	0.61	1.20	12.3	18.3	—	0.32	0.11	5.1	—	0.15	0.05	—	—	—	—	#	
40	0.39	0.80	0.41	—	5.20	—	1.42	—	—	—	—	—	0.83	—	—	—	#	従来合金

[0025]

[Table 2]

供試材 No.	処理方法	処理層もしくは 処理条件
40-1	プラズマ化学蒸着法 (PCVD)	Al <sub>2</sub> O <sub>3</sub>
40-2	プラズマ化学蒸着法 (PCVD)	TiN
40-3	大気溶射法	WC-Co
40-4	大気溶射法	TiB <sub>2</sub>
40-5	ガス置換法	520℃×10時間
40-6	塩浴浸置置換法	580℃×15時間

[0026] (1) Hot forging was performed about the ingot of No.1-24 and No.30-34 obtained by the processability evaluation vacuum induction melting furnace, and the propriety of the forging in that case estimated processability. (2) Abrasion loss abrasion loss carried out fixed time sliding of the test piece of 8mm round-head x25mm length by non-lubrication, forcing the end face of a test piece on the flat surface of the partner material of a tabular, and measu abrasion loss from the amount of losses of the test piece after an examination. In addition, SCN415 (annealed materi is used for partner material, and 10 m/min and test time moved the load reciprocally by 30kgf(s), and made sliding speed move reciprocally in 1.5 hours.

(3) The molten-metal-proof erosion \*\*\*\* aluminum erosion examination was immersed in the test piece for 3 hours into the 750-degree C molten metal of aluminum containing alloy AC4CH, and compared the erosion-proof nature b the weight ratio before and behind the examination of a test piece. About the zinc-proof-erosion examination, the tes piece was immersed into the 600-degree C molten metal of a zinc alloy ZAC2 for 20 hours, and the erosion nature w evaluated by the same method as an aluminum-proof erosion examination. The above result and the internal hardnes measurement result of each test piece after oxidation treatment are shown in Table 3, respectively.

[0027]

[Table 3]

合金 No.	塑性加工性評価 鍛造の可否 (注)	内部硬さ (HV)	摩耗量 ( $\times 10^{-4}$ g)	耐Al溶損性 減量率 (%)	耐Zn溶損性 減量率 (%)	備考
1	○	458	3	0.1	0	本発明合金
2	○	438	10	0.3	0	
3	○	450	3	0.2	0	
4	○	438	9	0.9	0	
5	○	466	3	0.2	0	
6	○	461	8	0.3	0	
7	○	472	15	0.1	0	
8	○	449	3	0.4	0	
	○	452	3	0.2	0	
10	○	430	3	0.7	0	
11	○	450	3	0.2	0	
12	○	449	3	0.1	0	
13	○	466	3	0.2	0	
14	○	443	3	0.1	0	
15	○	442	3	0.2	0	
16	○	451	3	0.3	0	
17	○	438	13	0.9	0	
18	○	467	3	0.1	0	
19	○	432	3	0.1	0	
20	○	453	13	0.5	0	
21	○	452	3	0.1	0	
22	○	421	3	0.1	0	
23	○	419	8	0.3	0	
24	○	413	3	0.2	0	
30	x	452	3	5.8	0	比較合金
31	○	245	134	1.6	0	
32	x	280	148	8.7	0.01	
33	x	455	84	20.6	1.72	
34	○	450	280	65.2	3.10	従来合金
40-1 PCVD (Al <sub>2</sub> O <sub>3</sub> )	—	382	4	9.8	0.01	
40-2 PCV (TiN)	—	388	4	10.1	0.01	
40-3 溶射 (WC-CO)	—	395	3	8.8	0.02	
40-4 溶射 (TiB <sub>2</sub> )	—	398	4	15.3	0	
40-5 ガス窒化	—	396	8	12.7	0.01	
40-6 塩浴浸炭窒化	—	392	14	5.5	0.01	

(注) ○…鍛造可能 x…鍛造不可能

[0028] As shown in Table 3, this invention alloy is very excellent in processability, and can perform hot forging easi on the other hand -- although No.30 which added the inside Cr of a comparison alloy so much, and 32 and 33 had ve

bad plastic-working nature, many cracks occurred under hot forging and in the ingot and it was not able to forge -- the amount of Cr(s) -- comparatively -- lowering -- coming out -- certain No. -- 31 and 34 do not have a problem in the processability, and hot forging was able to be performed easily moreover -- even if it compares the internal hardness after oxidation treatment of this invention alloy with 380 - 400HV of an alloy SKD61 conventionally -- hardness -- 410HV - 460HV -- it is -- casting -- public funds -- it can be equal to the use as type or a \*\*\*\*\* instrument enough Although the alloy of No.31 is excellent in processability, since the amount of nickel separates from the range of the alloy of this invention, it turns out that internal hardness falls remarkably. [0029] although the coat which makes the oxide of surface aluminum a subject when the addition of Si increases becomes porous [-like ], abrasion loss increases the abrasion loss of this invention alloy a little and the abrasion resistance falls a little -- any -- the former -- the abrasion loss of an alloy -- comparing -- almost -- this level -- or the abrasion resistance beyond it is shown and it is good however, the abrasion loss of a comparison alloy -- No. -- since the shortage of hardness of a base material and the adhesion of the coat which makes the oxide of aluminum a subject are insufficient about 31 and 32, and since the compactness of the coat which makes the oxide of aluminum a subject by too much addition of Si about No.33 fell extremely, during the abrasion test, ablation of a coat arose and abrasion loss increased Since the coat which makes the oxide of aluminum a subject during oxidation treatment by too much addition of C was destroyed, comparison alloy No.34 are considered that the wear-resistant improvement effect by the coat was not acquired.

[0030] Next, it turns out that the test piece in which the coat which performs oxidation treatment into this invention alloy, and makes the oxide of aluminum a subject about the molten-metal-proof erosion nature of each test specimen was made to form has very high erosion-proof nature to an aluminum containing alloy and a zinc alloy, and it excels very much even if it compares with what performed salt bath nitrosulphurizing to SKD61 of conventional alloy No.4 6. On the other hand, with the comparison alloy, since the coat to which comparison alloy No.34 of this invention all and equivalent level make the oxide of aluminum a subject during oxidation treatment by too much addition of C was destroyed for processability and internal hardness, the protective effect of a coat was not obtained but the molten-metal-proof erosion nature fell remarkably. Moreover, since hot forging was impossible, although comparison alloy No.30 which processed the test piece and performed oxidation treatment from the ingot were equivalent to this invention alloy about internal hardness and abrasion resistance, from the defect in the test piece by poor solidification, molten metal permeated and the erosion occurred.

[0031] this invention alloy is oxidation treatment. Although erosion-proof nature is raised by the coat which makes a subject the oxide of the aluminum which makes the oxide of aluminum a subject being formed in a front face, and intercepting a base material from molten metal It was admitted that molten metal permeated from the crack in the film imagined to be what conventional alloy No.40-1 which covered the alumina of this component with the plasma-chemistry vacuum deposition mostly with the coat generated in the covering process, SKD61 and molten metal of a base material reacted, and the erosion had occurred. In addition, in this example, although the result of the erosion-proof examination to an aluminum containing alloy and a zinc alloy was shown, generally erosions, such as metal mold by molten metal, advance by formation of a compound by contact to molten metal and the metal which are base materials, such as metal mold. therefore, casting of this invention -- public funds -- it is checked that the erosion-proof nature to the alloy of a copper system, other molten metal, for example, iron system, is excellent similarly to an aluminum system or a zinc system if [ material / of type or a \*\*\*\*\* instrument ]

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[Translation done.]